TABLE 2

TABLE 2. The calculated and experimental values

$J \backslash A$		193	195	197	199
1/2	Calculated	0.038	0 061	0.077	0.077
	Exptl.	0.038	0 061	0.077	0.077
3/2	Calculated	0.224	0 241	0.269	0 324
	Exptl.	0.224	0.241	0.269	0.324
5/2	Calculated	0.283	0 297	0.315	0.305
	Exptl.	0.258	0.261	0.279	0.317
7/2	Calculated	0.498	0 504	0.523	0.504
	Exptl.	0.508	0.525	0 548	0.495

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Forced convection flow past a plate with variable thermal conductivity

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Effect of variable thermal conductivity on heat transfer from a flat plate maintained at a constant temperature has been studied earlier by the author (Sinha 1967). In the present note such effect is considered when the heat flux at the plate surface is prescribed.

The energy equation governing the present problem (Sinha 1967), is

$$\rho C_p \left(Cy \frac{\partial T}{\partial x} \right) = \frac{\partial}{\partial y} \left(k \frac{\partial T}{\partial y} \right). \qquad (1)$$

The boundary conditions are

$$\left. \begin{array}{l} y = 0 (x > 0); \ \dfrac{\partial T}{\partial y} = -\dfrac{q}{k}, \\ y \to \infty; \quad T \to T_\infty, \end{array} \right\} \qquad \ldots \ (2)$$

where q is the heat flux per unit area of the plate.

With the substitutions

$$\eta = y \left(\frac{C}{9\alpha x} \right)^{1/3}, \quad T = T_\infty + \frac{q}{k} \left(\frac{9\alpha x}{C} \right)^{1/3} H(\eta)$$

and $\qquad k = k_0[1+\beta H(\eta)]$

equation (1) reduces to

$$H'' + 3\eta^2 H' - 3\eta H + \beta(HH'' + H'^2) = 0, \qquad \ldots \ (3)$$

where k_0 = thermal conductivity at $T = T_\infty$, $\alpha = k_0/\rho C_p$, β and C are constants and dashes denote differentiations with respect to η. The new boundary conditions are

$$\left. \begin{array}{l} \eta = 0; \quad H' = -1 \\ \eta \to \infty; \quad H \to 0. \end{array} \right\} \qquad \ldots \ (4)$$

The solution of equation (3) satisfying (4) is obtained by an integral method due to Epstein (1958), since our aim is to get qualitative results. In this method an appropriate initial form containing some free paramotors is assumed for the profiles which are then substituted in the integral equations to obtain new profiles, which are better approximations. The free parameters occuring in the initial profiles are determined by requiring the new profiles to satisfy all the boundary conditions of the problem. Thus satisfying (4), $H(\eta)$ and $H'(\eta)$ can be chosen as

$$H'(\eta) = -e^{-a\eta}, \quad H(\eta) = \frac{e^{-a\eta}}{a}, \qquad (5)$$

where the free parameter a is to be evaluated from the boundary condition at infinity. Integration of equation (3) with respect to η from 0 to η yields

$$H'(\eta) = H'(0) - 3\eta^2 H(\eta) + 9 \int_0^\eta \eta H(\eta) d\eta - \beta[H(\eta)H'(\eta) - H(0)]. \qquad (6)$$

Substituting (5) in the right-hand side of equation (6) and using (4), we get

$$H_1'(\eta) = -\left(1 + \frac{\beta}{a} - \frac{9}{a^3}\right) - \frac{9e^{-a\eta}}{a^3} - \frac{9\eta e^{-a\eta}}{a^2} - \frac{3\eta^2 e^{-a\eta}}{a} + \frac{\beta e^{-2a\eta}}{a} \qquad \ldots \ (7)$$

The parameter a can be determined from the condition $H'(\infty) = 0$, which suggests that a should satisfy

$$1+\frac{\beta}{a}-\frac{9}{a^3} = 0. \qquad \dots \quad (8)$$

Equation (7) then reduces to

$$H_1'(\eta) = -\frac{9e^{-a\eta}}{a^3} - \frac{9e^{-a\eta}}{a^2} - \frac{3\eta^2 e^{-a\eta}}{a} + \frac{\beta e^{-2a\eta}}{a}. \qquad (9)$$

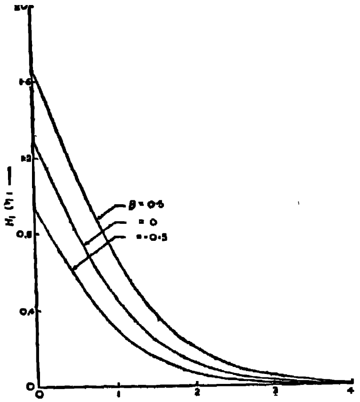

Figure 1. Dimensionless temperature profiles for various values of β.

Integrating (9) with respect to η and using the condition $H_1(\infty) = 0$, we obtain

$$H_1(\eta) = \frac{e^{-a\eta}}{a^4}(3a^2\eta^2+15a\eta+24) - \frac{\beta}{2a^2}. \qquad \dots \quad (10)$$

The function $H_1(\eta)$ has been plotted for different values of η and it is found that a linear variation of thermal conductivity with temperature results in a linear variation in the temperature distribution. Similar conclusion has been derived earlier by Sinha (1967).

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